

ATTACHMENT

Copy of US Provisional Application Serial Number. 60/295,060 filed June 1, 2001 entitled
“Improved Wireless Communications Systems and Methods for a
Communications Computer”

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES PROVISIONAL PATENT APPLICATION

for

IMPROVED WIRELESS COMMUNICATIONS SYSTEMS AND METHODS
FOR A COMMUNICATIONS COMPUTER

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Background of the Invention

The invention pertains to wireless communications and, more particularly, to communications computers. The invention has application, by way of non-limiting example, in improving the capacity of cellular phone base stations.

Code-division multiple access (CDMA) is used increasingly in wireless communications. It is a form of multiplexing communications, e.g., between cellular phones and base stations, based on distinct digital codes in the communication signals. This can be contrasted with other wireless protocols, such as frequency-division multiple access and time-division multiple access, in which multiplexing is based on the use of orthogonal frequency bands and orthogonal time-slots, respectively.

A limiting factor in CDMA communication and, particularly, in so-called direct sequence CDMA (DS-CDMA), is the interference between multiple simultaneous communications, e.g., multiple cellular phone users in the same geographic area using their phones at the same time. This is referred to as multiple access interference (MAI). It has effect of limiting the capacity of cellular phone base stations, since interference may exceed acceptable levels -- driving service quality below acceptable levels -- when there are too many users.

A technique known as multi-user detection (MUD) reduces multiple access interference and, as a consequence, increases base station capacity. MUD can reduce interference not only between multiple signals of like strength, but also that caused by users so close to the base station as to otherwise overpower signals from other users (the so-called near/far problem). MUD generally functions on the principle that signals from multiple simultaneous users can be jointly used to improve detection of the signal from any single user. Many forms of MUD are known; surveys are provided in Moshavi, "Multi-User Detection for DS-CDMA Systems," IEEE Communications Magazine (October, 1996) and Duel-Hallen et al, "Multiuser Detection for CDMA Systems," IEEE Personal Communications (April 1995). Though a promising solution to increasing the capacity of cellular phone base stations, MUD techniques are typically so computationally intensive as to limit practical application.

An object of this invention is to provide improved methods and apparatus for wireless communications. A related object is to provide such methods and apparatus for multi-user detection or interference cancellation in code-division multiple access communications.

A further object of the invention is to provide such methods and apparatus as can be cost-effectively implemented and as require minimal changes in existing wireless communications infrastructure.

A still further object of the invention is to provide methods and apparatus for executing multi-user detection and related algorithms in real-time.

A still further object of the invention is to provide such methods and apparatus as manage faults for high-availability.

Summary of the Invention

These and other objects are met by the invention which provides, in one aspect, a communications computer, referred to as the "MCW-1" (among other terms) in the materials that follow, and methods of operation thereof. An overview of that system is provided in the section entitled "Communications Computer," beginning on page 5 hereof. A more complete understanding of its implementation may be attained by reference to the other attached materials.

In view of those materials, aspects of the invention include, but are not limited to the following:

- architecture and operation of a communications computer for a wireless communications system, including a fully programmable computer inserted into base transceiver station (BTS) to support compute-intensive and/or highly data-dependent functions such as adaptive processing and interference cancellation

These and other aspects of the invention (including utilization of the aforementioned methods and aspects for other than wireless communications and/or interference cancellation) are evident in the materials that follow.

Detailed Description of the Invention

See the attached materials on pages 5 – 11 hereof, providing description and block diagram of a preferred structure and operation of a communications computer for wireless applications according to the invention.

The aforementioned materials pertain to improvements on the methods and apparatus described in United States Provisional Application Serial No. 60/275,846, filed March 14, 2001, entitled **IMPROVED WIRELESS COMMUNICATIONS SYSTEMS AND METHODS** and United States Provisional Application Serial No. 60/289,600, filed May 7, 2001, entitled **IMPROVED WIRELESS COMMUNICATIONS SYSTEMS AND METHODS USING LONG-CODE MULTI-USER DETECTION**, the teachings of both of which are incorporated herein by reference and copies of at least portions of which are attached hereto. Those copies bears the U.S. Postal Service Express Mail label number of both prior filings, as well as that of this filing (the latter being referred to as the “New Exp. Mail Label No.”).



Communications Computer

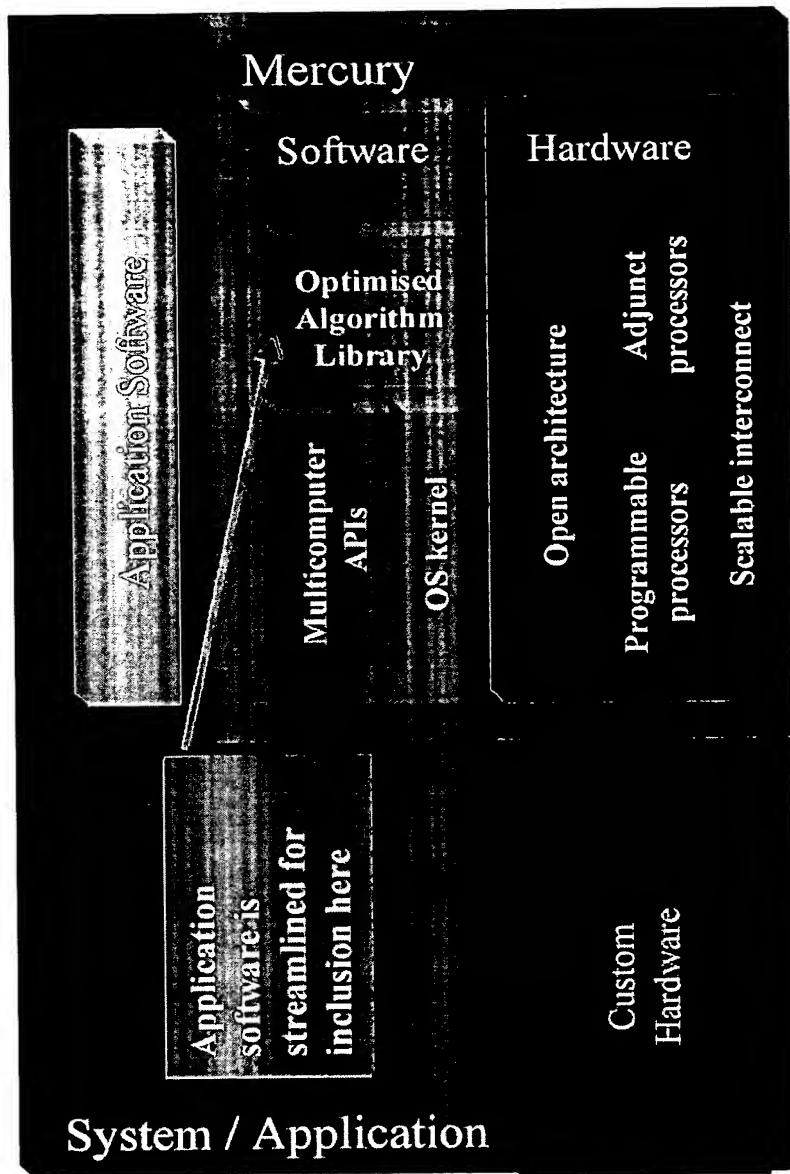
- Fully programmable computer inserted into base transceiver station (BTS) to support compute-intensive and/or highly data-dependent functions such as adaptive processing and interference cancellation
 - Overcomes rigidity of ASIC-based application implementation
 - Overcomes limitations of DSP instruction sets
 - Overcomes traditional inter-processor bandwidth limitations
 - By using modern processor interconnect technology rather than busses
 - Enables remote modification of functionality by software download
- High-profile applications:
 - Multi-user detection (MUD)
 - Interference cancellation
 - Smart and adaptive antenna processing
 - Interference avoidance



Communications Computer (Cont.)

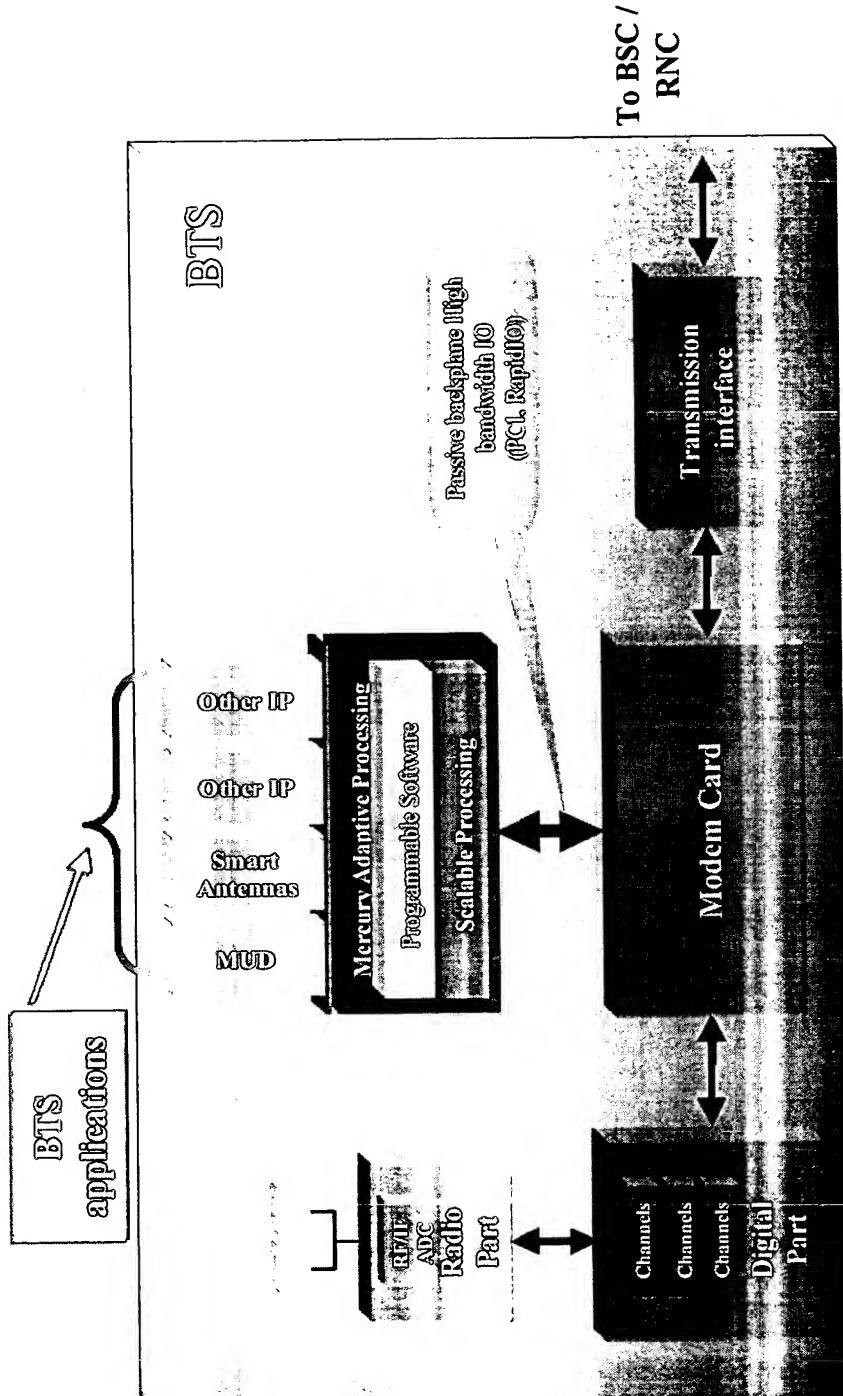
- Multiple communications computers can be interconnected to promote
 - Load balancing among cell site sectors
 - Improved fault resilience
 - Additional algorithm sophistication/complexity
 - Functionality of additional algorithms
- Communications computer concept can be extended by interconnection to encompass full BTS functionality

Mercury Generic Model

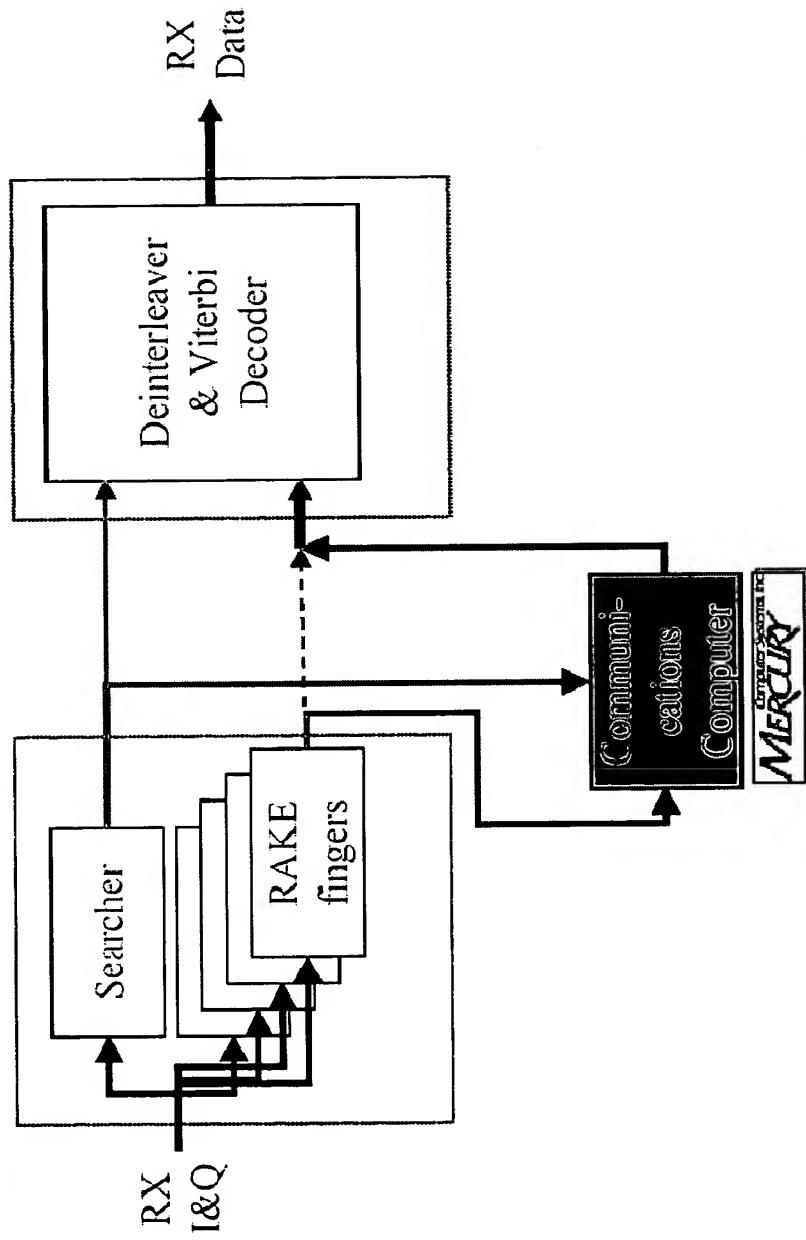


Open
interface
standards

Communications Computer Concept



 **Wideband CDMA Multi-User Detection**

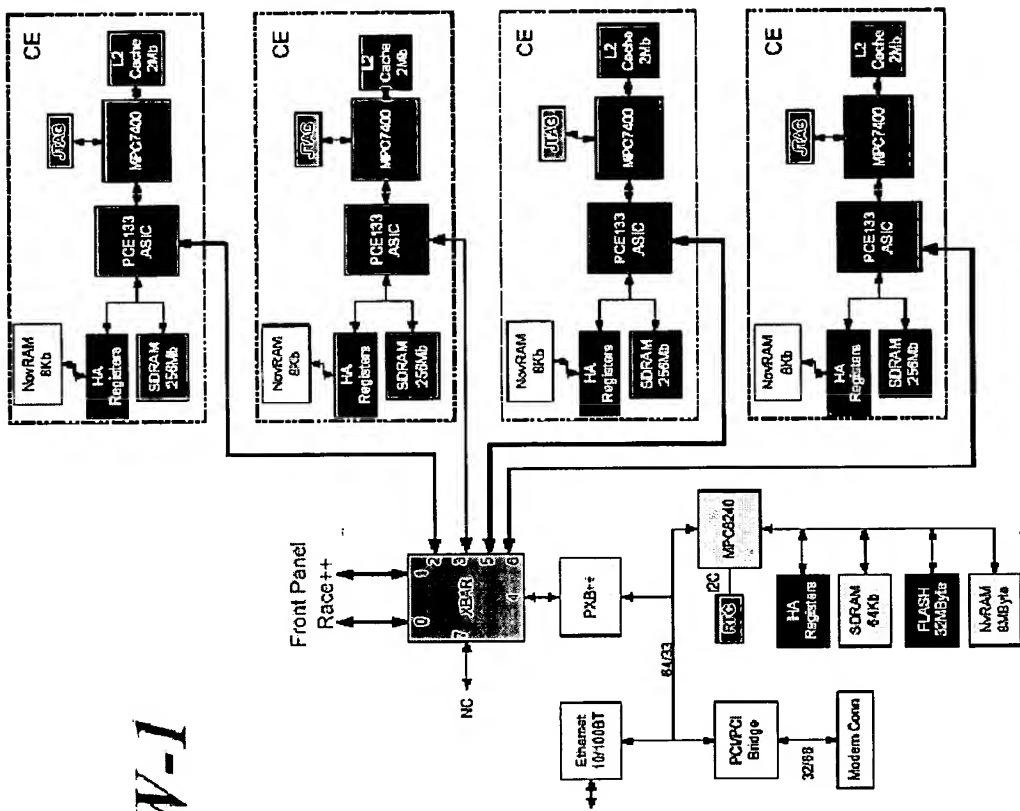




Communications Computer Prototype: *MCW-1*

- Interconnectable telco-grade multicomputer boards and system software suitable for MUD, interference cancellation, and other adaptive processing applications
 - Hardware: Four G4/Nitros and SDRAM; plus MPC8240, watchdogs, NVRAM, PCI and Enet connectivity...
 - Scalable up and down in complexity
 - Software: Application; autonomous fault monitoring, detection, isolation, recovery; automatic remote software update; remote access via embedded web server

MCW-1



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES PROVISIONAL PATENT APPLICATION

for

IMPROVED WIRELESS COMMUNICATIONS SYSTEMS AND METHODS
USING LONG-CODE MULTI-USER DETECTION

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Background of the Invention

The invention pertains to wireless communications and, more particularly, to methods and apparatus for interference cancellation in code-division multiple access communications. The invention has application, by way of non-limiting example, in improving the capacity of cellular phone base stations.

Code-division multiple access (CDMA) is used increasingly in wireless communications. It is a form of multiplexing communications, e.g., between cellular phones and base stations, based on distinct digital codes in the communication signals. This can be contrasted with other wireless protocols, such as frequency-division multiple access and time-division multiple access, in which multiplexing is based on the use of orthogonal frequency bands and orthogonal time-slots, respectively.

A limiting factor in CDMA communication and, particularly, in so-called direct sequence CDMA (DS-CDMA), is the interference between multiple simultaneous communications, e.g., multiple cellular phone users in the same geographic area using their phones at the same time. This is referred to as multiple access interference (MAI). It has effect of limiting the capacity of cellular phone base stations, since interference may exceed acceptable levels -- driving service quality below acceptable levels -- when there are too many users.

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A still further object of the invention is to provide such methods and apparatus as manage faults for high-availability.

Summary of the Invention

These and other objects are met by the invention which provides, in one aspect, a wireless communications system, referred to as the "MCW-1" (among other terms) in the materials that follow, and methods of operation thereof. An overview of that system is provided in the document entitled "Software Architecture of the MCW-1 MUD Board," immediately following this Summary. A more complete understanding of its implementation may be attained by reference to the other attached materials.

In view of those materials, aspects of the invention include, but are not limited to, the following:

- methods and apparatus for long-code multi-user detection (MUD) in a wireless communications system.

These and other aspects of the invention (including utilization of the aforementioned methods and aspects for other than wireless communications and/or interference cancellation) are evident in the materials that follow.

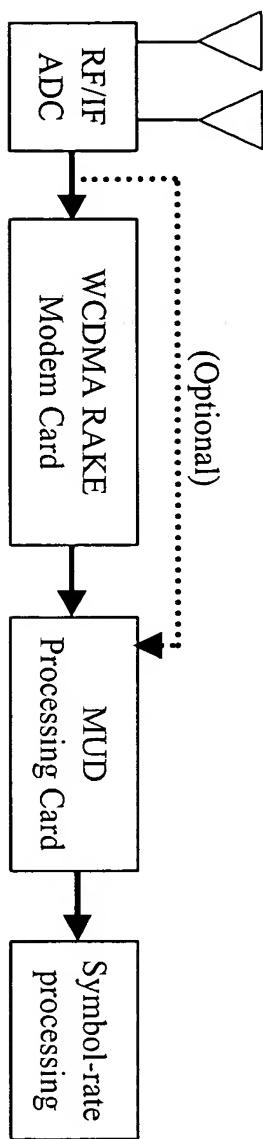
Detailed Description of the Invention

See the attached materials on pages 5 – 12 hereof, providing a block diagram of a preferred algorithm for long code MUD which includes identification of (roughly) how many GOPS are involved in each major function; a diagram showing interfaces between a long code MUD processing card according to the invention and a modem, e.g., of the type provided by Motorola (or another supplier of such components); and two block diagrams of the same BASELINE 0 board hardware architecture at a top level identifying the processing nodes. The attached diagram entitled “Long-code Mapping to Hardware” illustrates support of 64 users for long code MUD and shows parts of the long code MUD algorithm supported by each processing node. The diagram entitled “Short-code Mapping to Hardware” illustrates support of 128 users for short code MUD and shows parts of the short code MUD algorithm would be supported by each processing node.

The aforementioned materials pertain to improvements on the methods and apparatus described in United States Provisional Application Serial No. 60/275,846, filed March 14, 2001, entitled IMPROVED WIRELESS COMMUNICATIONS SYSTEMS AND METHODS, the teachings of which are incorporated herein by reference and a copy of which is attached hereto. That copy bears the U.S. Postal Service Express Mail label number of both the original filing, as well as that of this filing (the latter being referred to as the “New Exp. Mail Label No.”).

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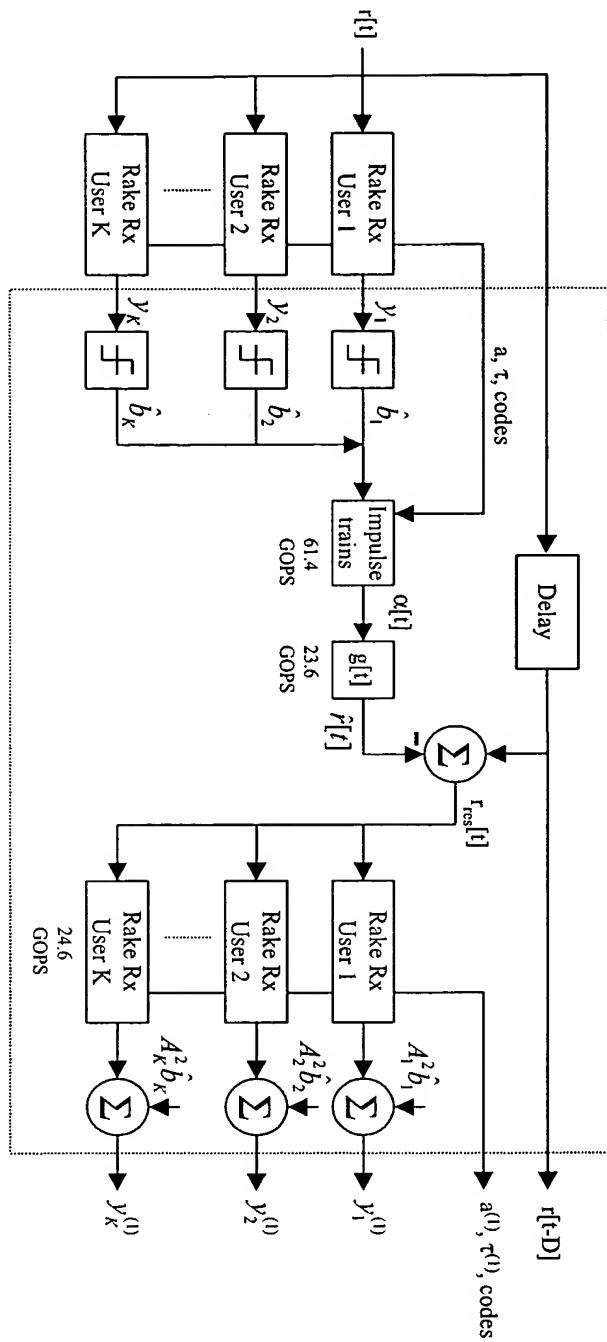
Long-Code Multiuser Detection Enhancement Concept



Optional antenna-stream input to MUD processing card allows multiple-stage interference cancellation and multiuser channel-amplitude estimation.



Block Diagram of Multiple-Stage Long-Code Algorithm

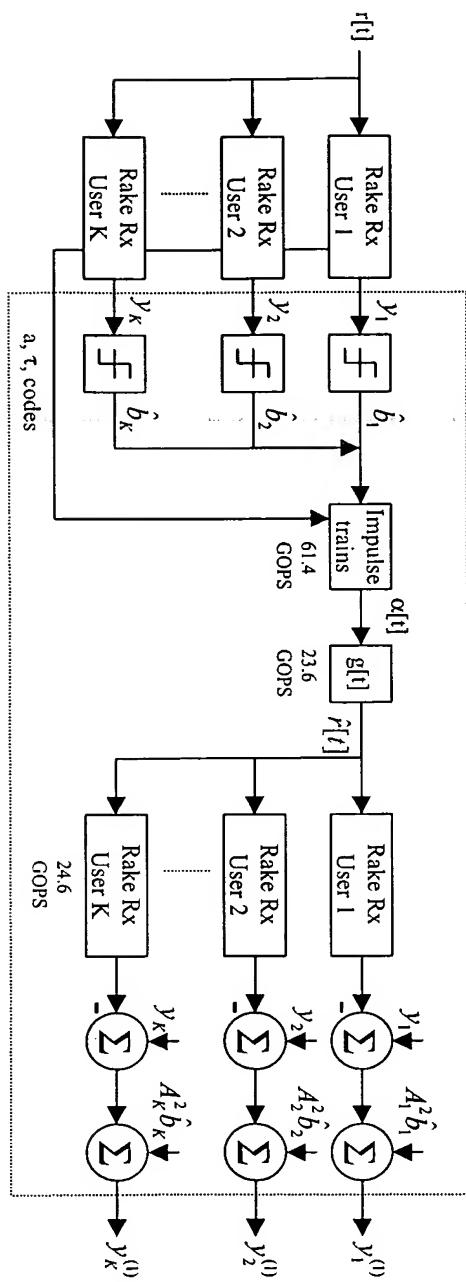


Computational complexity figures (GOPs) are based on

- 128 SF 256 users
- 4 multipath fingers
- 8 samples per chip



Block Diagram of Single-Stage Long-Code Algorithm



Computational complexity figures (GOPs) are based on

- 128 SF 256 users
- 4 multipath fingers
- 8 samples per chip

MUD Interface to Modem

Bandwidth: 16 MB/s (Optional)

Modem Card

User codes, ...

User #1
User #2
User #K

Data
from
A/D

Searcher
receiver

\hat{r}_{kq}

MUD
Processing
Card

y_k
 $y_k^{(N)}$

Finger
receiver
 $\hat{a}_{k1} \hat{r}_{k1}$

Finger
V_{1,4}
V_{1,3}
V_{1,2}

MRC
 y_k

Bandwidth: 16 MB/s

MERCURY
Systems Inc.

Data Transferred to or from MUD Processing Card

Inputs

- Frame number
- Post-MRC matched-filter outputs y_k for DPCCH and DPDCHs
- Number of DPDCHs
- DPCCH slot format
- Number of rake fingers
- Number of antennas used
- Channel amplitude estimates a_{kq}
- Channel lag estimates τ_{kq}
- Spreading factor SF_k
- Code number
- Compressed mode information
 - Compressed mode flag, Compressed mode frame, N_{first} , T_{GL}
- Amplitude ratios β_{dk}, β_{ck}
- Antenna streams $r[t]$ (Optional)

• Outputs

- Cleaned data bit estimates b_k

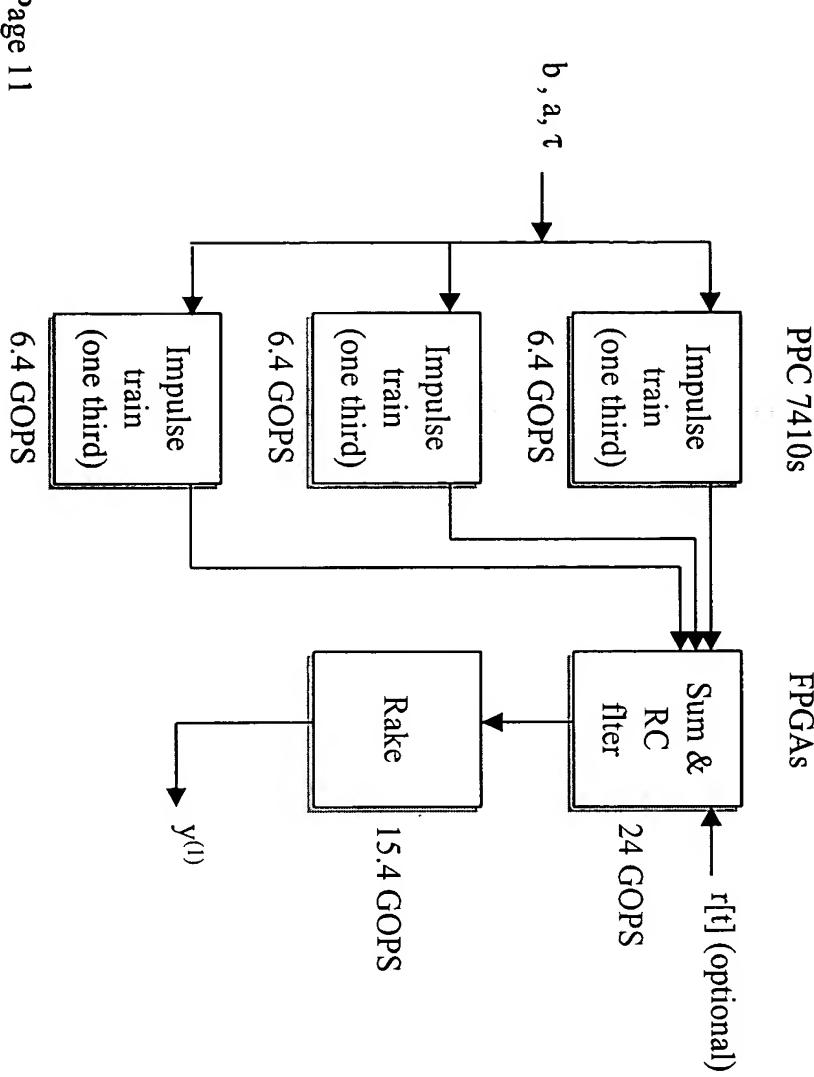
Long-code MUD Processing

Card Interface Bandwidth

Data Description	BW (MB/s)
Antenna streams	16.00
Post-MRC outputs y_k	3.260
Channel amplitude estimates a_{kq}	6.144
Channel lag estimates τ_{kq}	0.001
Cleaned data bit estimates b_k	1.920
TOTAL	27.325



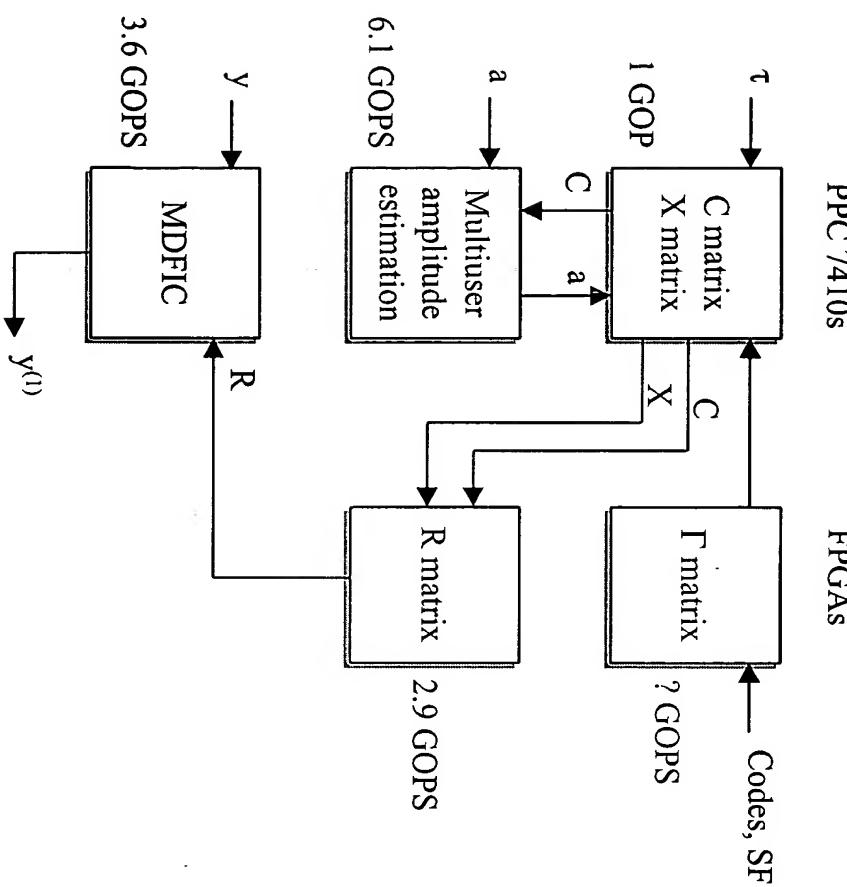
Long-code Mapping to Hardware



Short-code Mapping to Hardware

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